Space Weather Technical Forecast

Issued on Monday, 17 July 2023 at 01:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Minor/Moderate R1/R2 Blackouts likely throughout G1-G2/Moderate likely Storms Day 1 (17 July), and possible Day 2 (18 Jul).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate, with three M-flares observed, peaking M4 at 16/1746 UTC from AR3363 (in the southwest quadrant). There are currently eight sunspot regions on the visible disc. AR3363 persists as a large and mature region with a small delta spot, but has decreased slightly in areal extent as it approaches the southwest limb. AR3372 is the other large region on the disc, and the source of the other two M-flares. This is a large open region in the northeast quadrant, with a simple and symmetric leader spot, but a more complex trailer containing small delta spots. AR3373, also in the northeast, is also a moderately sized region, with mature penumbra having developed amongst its intermediate spots, and with ongoing growth occurring in this region.

Several CMEs were observed leaving the Sun over the past 24 hours, however none of them are currently considered Earth-directed. The largest and fastest CMEs originated from a region located well beyond the western horizon. Further CMEs from AR3363 have been analysed as not being Earth-directed. A filament eruption also occurred in the northwest, however no CME could be identified from it.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by ACE and DSCOVR at L1, showed the arrival of a CME from a yet to be determined source. The solar wind rose sharply from background, near 350 km/s to around 440-500 km/s at 17/1837 UTC. The density also rose from below average to above average levels. The total magnetic field (IMF), Bt, was initially weak, below 7nT but jumped sharply at 17/1837 UTC to then persist at Moderate, 11-15nT. The north-south component become moderately southward at this time, falling to a minimum of -11nT, before gradually rotating to be positive at the end of the period, reaching a maximum of 7nT. Phi angle was negative (Towards the Sun). Geomagnetic activity was Quiet (Kp 0-1) at first, but rose to be Unsettled to Active (Kp 3-4) from 16/1800 UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, rose sharply above the S1 threshold 16/0635-0905 UTC, reaching a peak of 18pfu at 16/0735 UTC, before slowly easing to around 1-3 pfu during the following hours. High energy electron flux (greater than 2MeV) was at background levels. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a decreasing trend. A fluence of 1.35e6 pfu was recorded at 16/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is expected to remain Moderate, with occasional M-class flares and a slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: Current CME influence is expected to gradually ease early on day 1 (17 Jul). A further CME is then likely to arrive on day 1 (17 Jul) from the combined C8.8 flare and filament eruption on the 14 Jul. The strength of any impact is low confidence, due to uncertainties about the material content of any CME, along with limited imagery for analysis,

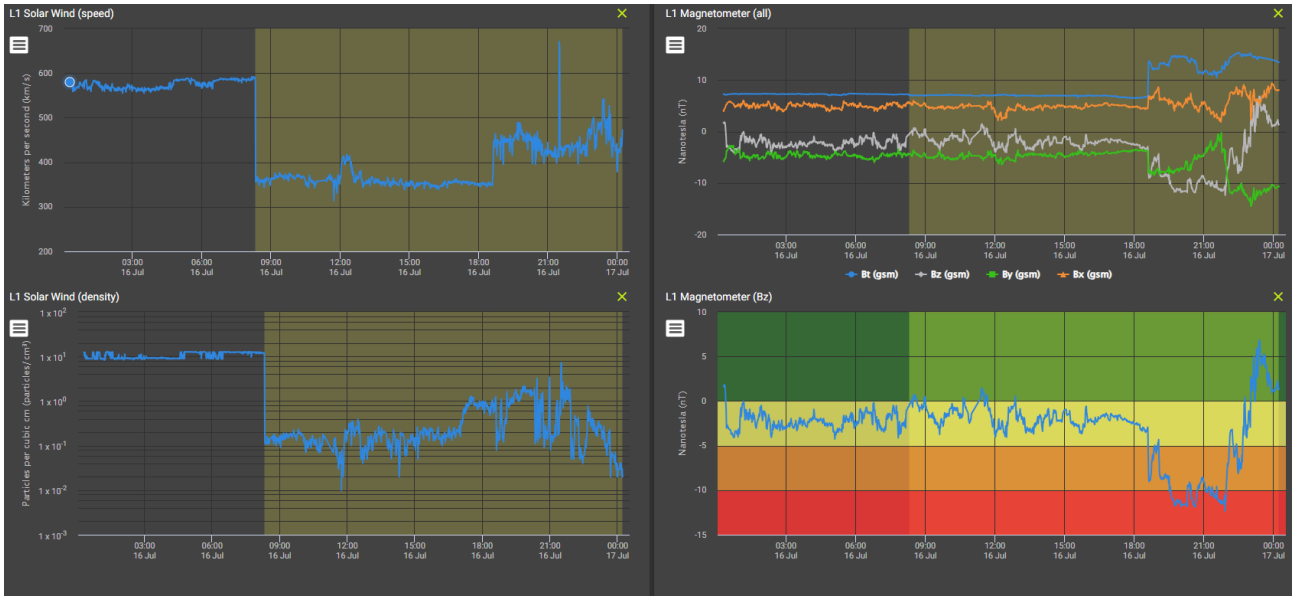
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

however this is currently expected to arrive 17/1400 +/- 10 hours with effects continuing into day 2 (18 Jul). There is a slight chance of a small enhancement from the HSS of CH24 later day 3 (19 Jul), but otherwise solar winds are likely to ease towards background. Unsettled to Active geomagnetic activity is likely at first, with a chance of G1 Minor storms, easing for a time day 1 (17 Jul) before the arrival of the CME later in the day. G1-G2 Minor to Moderate storms then likely. Ongoing CME effects are expected into day 2, before gradually easing back to mainly Quiet with Unsettled spells by day 3 (19 Jul). However any further enhancement from CH24 is likely to bring a spell of Active conditions, most likely later day 3.

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S1/Minor Storm threshold through the period, should any large flares occur. However the probability is low and expected to decrease over the following days. An increase in observed flux may also occur just ahead of the CME arrival expected on day 1 (17 Jul) High energy electron flux (greater than 2MeV) is expected to be at mostly background, perhaps briefly Moderate to High later in the period, however fluence is most likely to remain below the Active (1e8 integrated pfu) threshold throughout.

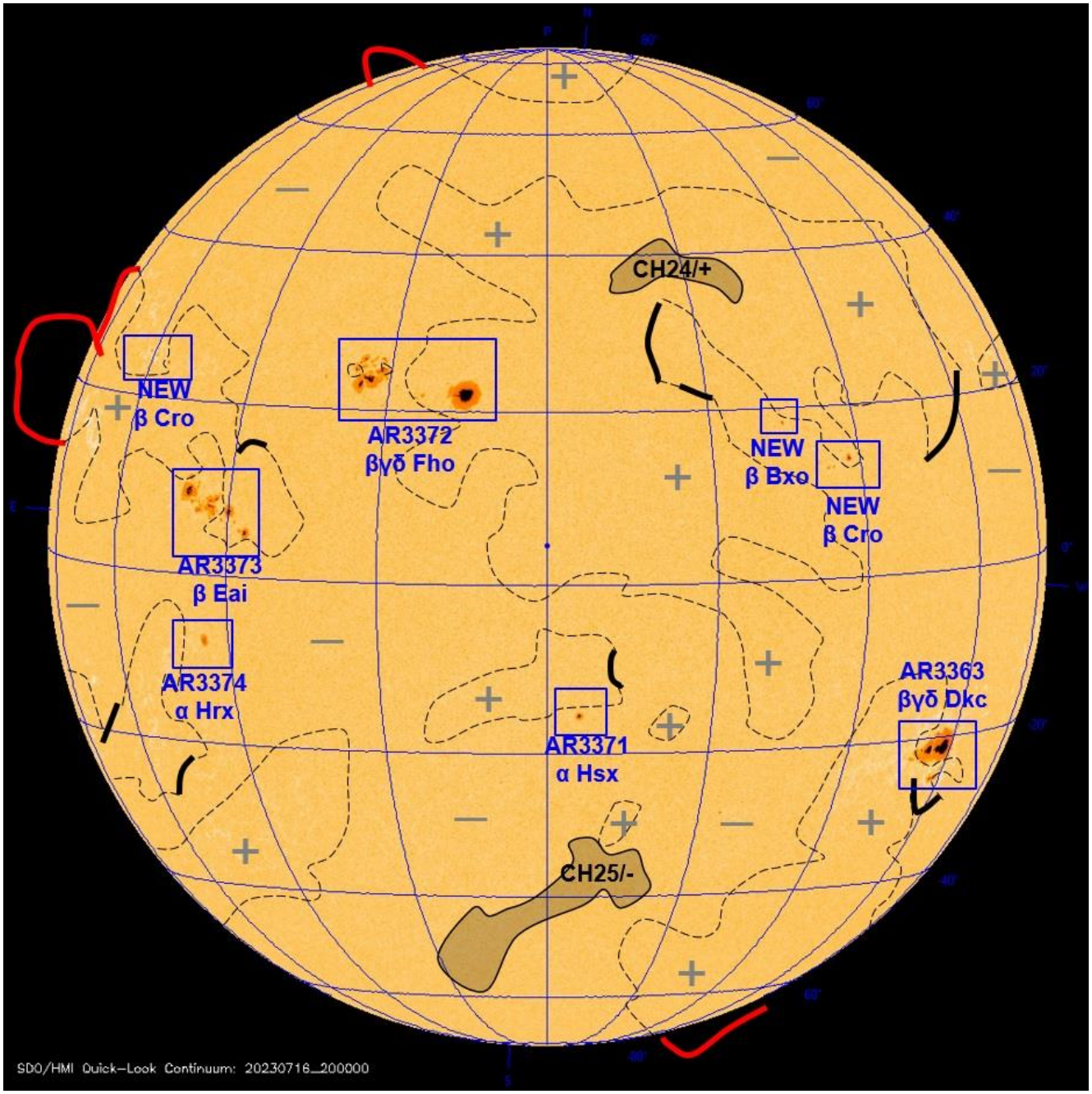
Figure 1a. Solar wind showing CME arrival (shading showing change to using ACE from DSCOVR due to incorrect speed and density)



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 17/2000 UTC.



.

Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

Ongoing CME influence is expected at first day 1 (17 Jul), giving a chance of G1/Minor Geomagnetic Storms at first, before easing during the morning. A further CME is then expected to arrive, from the filament eruption on 14 Jul. This is a complex CME to assess, with uncertain material content of the CME, limited imagery and also other non-Earth-directed CMEs contaminating the analysis, however current expectation is for arrival at 17/1400 +/- 10hrs. Ongoing effects are then possible into day 2 (18 Jul) before easing later in the day.

The arrival of this CME may be followed by a further slight enhancement from CH24/+. This is located on the northern disc, however the lack of persistence data, and its small and indistinct appearance all add to the low confidence that any notable enhancement from this feature will be observed. This is most likely to occur either late day 2 or through day 3 (18-19 Jul).

Geomagnetic activity is likely to Unsettled to Active at first, with a chance of G1 Minor storms, but easing for a time day 1 (17 Jul). The arrival of the CME later in the day will bring a likelihood of G1-G2 Minor to Moderate storms, and there is a slight chance of G3 Strong Storms. Ongoing CME effects are expected into day 2, before gradually easing back to mainly Quiet with Unsettled spells by day 3 (19 Jul). However any further enhancement from CH24 is likely to bring a spell of Active conditions, most likely later day 3.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	40	5	5
Strong	G3	No	20	10	1	1
Severe	G4	No	2	1	1	1
Extreme	G5	No	1	1	1	1

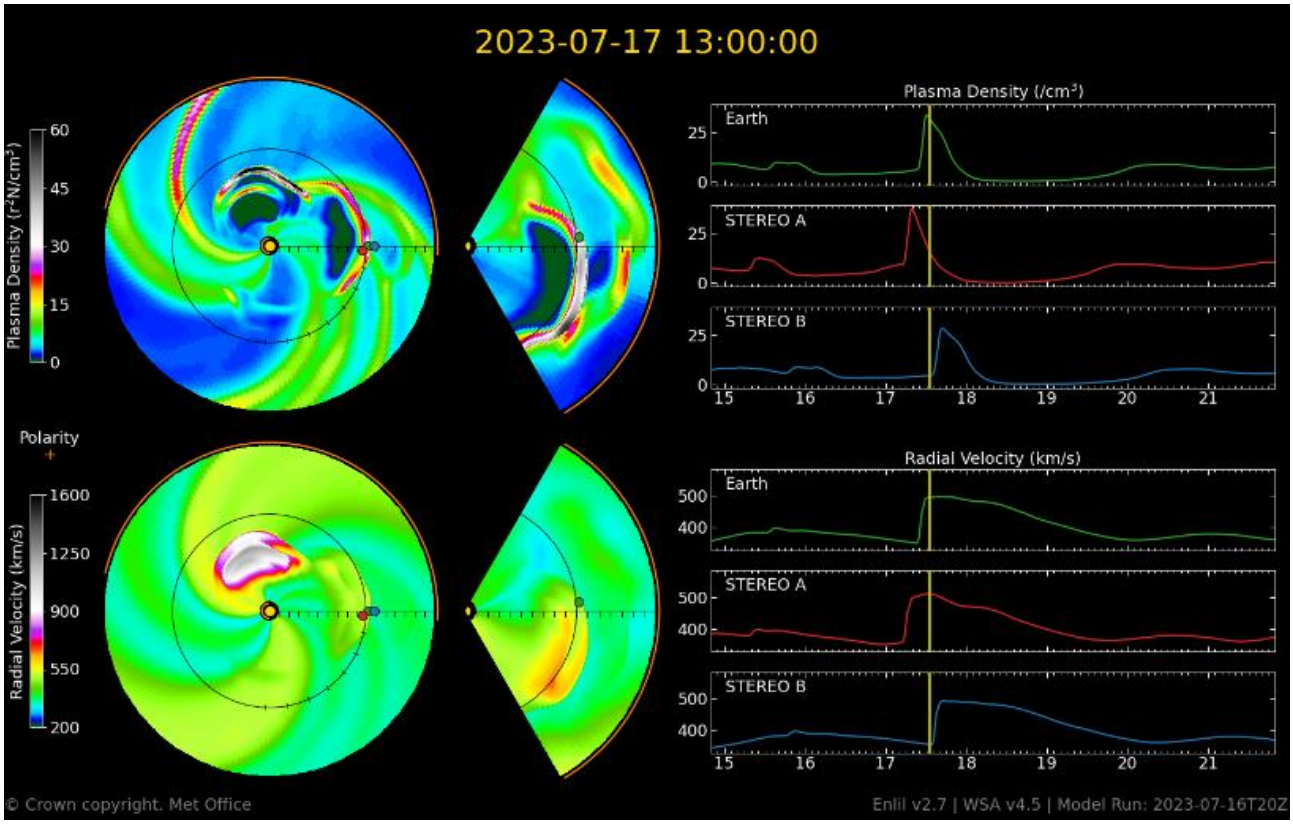
Geomagnetic Activity - Earthbound Coronal Mass Ejections

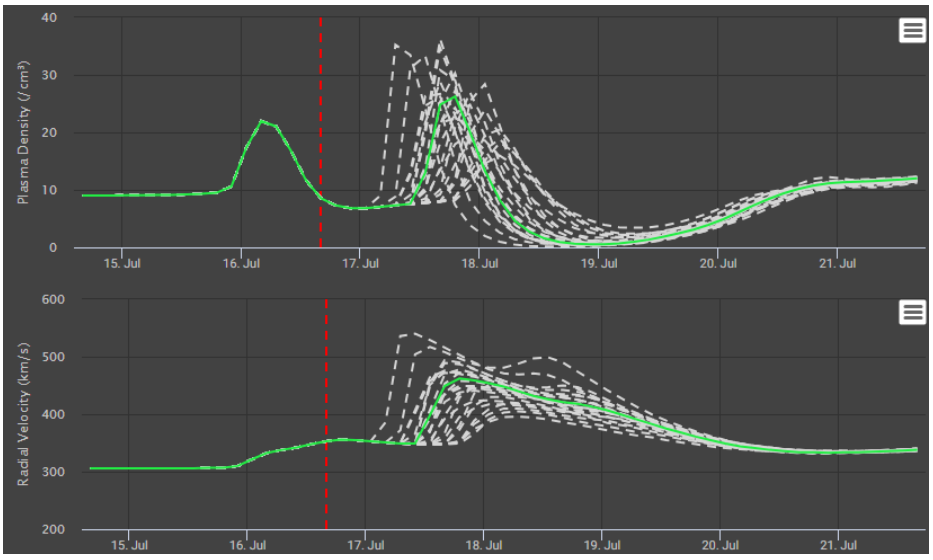
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/2155	Asymmetric Full	C8.8 flare of AR3370 and filament eruption	S Centre	832 km/s	17/1400 UTC	Low confidence on strength of impact Limited imagery for analysis

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2: Enlil and ensemble





Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

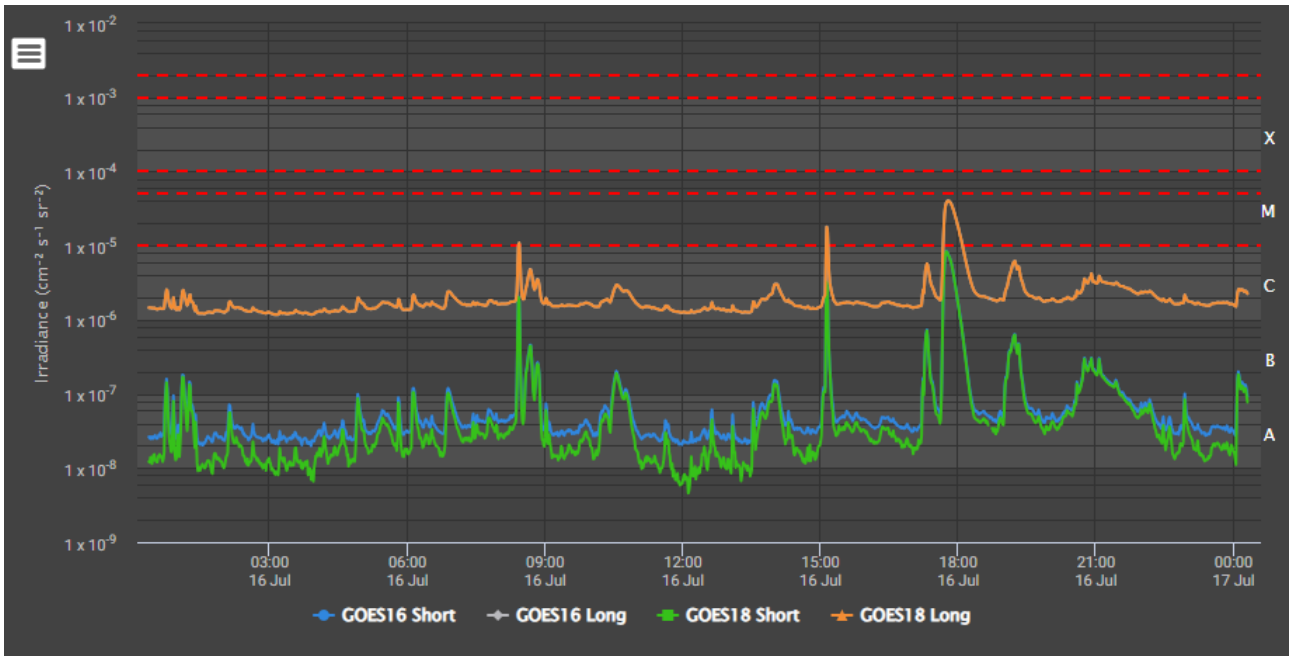
Radio Blackouts - X-Ray Flares:

Moderate activity has continued with three M-flares in the last 24 hours. Peak flare was an M4.0 from AR3363 in the southwest, with an impulsive M1.7 and M1.0 also observed from AR3372 in the northwest. Further M-flares are forecast with activity remaining moderate. There is a slight chance of X-class flares.

AR3363 is a large region, but now showing some slight signs of simplification, although this may be a product of it now approaching the southwest horizon. Despite this, a small delta spot persists to in a secondary penumbral region to the south of the main large spot. AR3372 in the northwest is a large, wide, but also open spot with a broadly simple bipolar structure and simple symmetric leader spot, but a more complex broken trailer, with a couple of small delta regions. The other region currently of note is AR3373, a moderately sized but gradually growing spot, also in the northwest. This has developed a number of small intermediate spots with mature penumbra and while it's currently relatively simple in magnetic structure, further development is possible. The other five regions on the disc, giving eight in total, are currently smaller and simpler.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	75	70	60	60
Very Active	R3 to R5 X Class	No	15	15	10	10

Figure 3: GOES-16 X-ray Flux



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

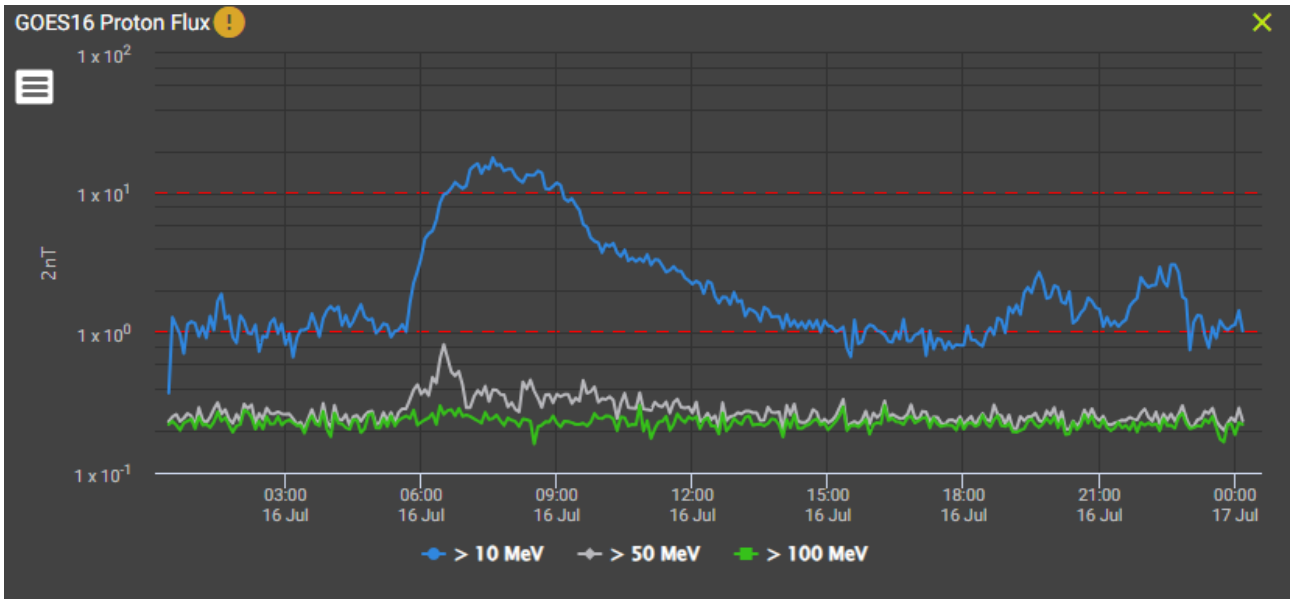
Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux rose to be above the S1 threshold (10 pfu) 16/0635-0905UTC, before gradually easing back towards background. This rise was likely due to a significant flare, associated with a fast CME that was observed on the far-side, just over the western horizon early on 16 Jul.

Flux remains slightly above normal background, and further increases remain possible. These potentially from any flaring, mainly from sunspots on the western hemisphere disc, or further events over the western limb. Furthermore, the arrival of a CME on day 1 (17 Jul) has the potential to sweep up the protons ahead of it, increasing the flux for a short period as it arrives. This will give a chance of further periods of S1 Minor Storm levels, mainly day 1 (17 Jul) before the proton flux is expected to very gradually ease through the period.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	25	15	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 >10MeV, >50MeV and >100 MeV Proton Flux



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) at GEO has been at background. With ongoing and arriving CMEs expected on day 1 (17 Jul), and any influence continuing into day 2 (18 Jul), flux is expected to remain mostly background until at least later on day 2. This may then rise to give Moderate, perhaps briefly High flux day 3 and day 4 (19 and 20 Jul)

The associated 24-hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold, with REFM giving a reasonable guide of background conditions at first, before any CME enhancement occurs. Thereafter confidence is lower, but likely remaining below the Active level.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.